THE EFFECTS OF CAFFEINE UPON THE GERMINATION AND GROWTH OF SEEDS

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The following report contains the results of some preliminary experiments made to ascertain the effect of subjecting seeds to the action of caffeine.

The method adopted was to take two equal quantities of each sort of seed and place one lot in 1 per cent. solution of caffeine in tapwater, the other in tapwater alone. Both sets were then left for twenty-four hours in a thermostat at 25° C. At the end of this period each portion of seed was washed on a muslin filter with tapwater and sown in ordinary coarse garden sand. Very small seeds were first mixed with a little dry sand, so as to allow of equal distribution. The sowings were made in red flowerpot saucers, placed in the laboratory windows and watered as required. Care was taken that the conditions of light and temperature were as far as possible equal. The results observed are given in tabular form at the end of this report, Table I.

Although the list of seeds is comparatively short, still the results obtained are so uniform that they can hardly be attributed to chance. In every case except one (nasturtium) the seeds which had been treated with caffeine were later in germinating than the tapwater controls, and in a great majority of cases fewer seeds germinated in the caffeine groups. In the course of growth the caffeine seeds were at first relatively less vigorous than those from tapwater, and in many cases they remained so till the end of the experiment. In three caffeine groups no seeds germinated. In no instance except the nasturtium had the caffeine groups any advantage over the controls.

The well-known action of caffeine upon striped muscle and its effect on plant cells, as described by Bokorny,[1] show that it has a disintegrating effect upon certain vegetable and animal proteins. In the case of muscular tissue there is considerable resemblance between the action of caffeine and that of chloroform, toluol, ether, alcohol, and similar bodies. With plants, on the contrary, there would appear to be a notable difference. This may be shown by an adaptation of the method

described by Armstrong[2] for the rapid detection of emulsine, and by Waller[3] for the colorimetric estimation of hydrocyanic acid. The following, Table II, demonstrates the difference in action of two members of the chloroform group on the one hand and caffeine and formaldehyde on the other.

TABLE II

			Condition of solution after 3 hours at 37° C.	Condition of solution after 24 hours at 37° C.
Laurel leaf immersed in	Na picrate solution Aqua	5 c.c. 35 c.c.	Unchanged	Unchanged
,,	Na picrate solution Aqua Chloroform	5 c.c. 35 c.c. 12 drops	Dark-red-brown	Dark-red-brown
,,	Na picrate solution Aqua Toluol	5 c.c. 35 c.c. 1 c.c.	Dark-red-brown	Dark-red-brown
,,	Na picrate solution 1% Caffeine solution	5 c.c. 35 c.c.	Unchanged	Unchanged
,,	Na picrate solution 1% Formaldehyde	5 c.c. 35 c.c.	Unchanged	Unchanged
,,	Na picrate solution 10% Formaldehyde	5 c.c. 35 c.c.	Unchanged	Unchanged

Even when the immersion in caffeine solution was prolonged to forty-eight hours there was no production of hydrocyanic acid; but the same leaf, placed afterwards in chloroform water with sodium picrate, quickly turned the solution brown. The two protoplasmic poisons, caffeine and formaldehyde, obviously act upon the laurel leaves in a manner different from that of chloroform.

It seems not unlikely that caffeine may produce its effects both on muscle and on seeds by increasing the activity of a protease. If this were the case it might be expected that in small doses it would stimulate germination and growth. Caffeine in dilute solution applied to muscle increases the response to stimulation, whereas in greater concentration it induces rigor and death. I am inclined to ascribe the exceptional position of the nasturtium seeds in these experiments to the density of the seed-covering limiting the access of caffeine.

In the meantime the present paper brings evidence that caffeine in 1 per cent. solution may retard or even prevent the germination and growth of seeds. In a paper which has just appeared Bokorny[4] gives some instances of the deleterious effects of caffeine upon seedlings.

TABLE I

Name of seed	Previous treatment 24 hours at 25° C. in	Quantity	Date of planting	Sprouts first visible	Condition 4 weeks after planting
Endive	Tap water	0·5 g.	29/4/11	7/5/11	Fewer seeds have germinated in Caffeine group. The growth in both groups is about equal.
,,	1% Caffeine	0·5 g.	,,	11/5/11	
Onion	Tap water	0·5 g.	,,	11/5/11	Fewer seeds have germinated in the caffeine group, and they are shorter and thinner than those of the tap-water group.
,,	1% Caffeine	0·5 g.	,,	3/6/11	
Lettuce	Tap water	0·5 g.	,,	8 5/11	Fewer seeds have germinated in the caffeine group. The growth in both groups about equal.
,,	1% Caffeine	0·5 g.	,,	12/5/11	
Cress	Tap water	0·5 g.	,,	5/5/11	Fewer seeds have germinated in the caffeine group. Growth about equal.
,,	1% Caffeine	0·5 g.	,,	7/5/11	
Turnip	Tap water	0·5 g.	,,	5/5/11	About the same number have germinated in each group, and the seedlings are about equally vigorous.
,,	1% Caffeine	0·5 g.	,,	7/5/11	
Carrot	Tap water	0·5 g.	30/4/11	12/5/11	Fewer seeds have germinated in the caffeine group, and they are less vigorous than those of the tap-water group.
,,	1% Caffeine	0·5 g.	,,	22/5/11	
Radish	Tap water	0·5 g.	,,	4/5/11	About the same number of seeds have germinated in each group and the seedlings are about equally vigorous.
,,	1% Caffeine	0·5 g.	,,	6/5/11	
Spinach	Tap water	0·5 g.	,,	6/5/11	About equal in number and vigour.
,,	1% Caffeine	0·5 g.	,,	8/5/11	
Sweet peas ...	Tap water	12	,,	9/5/11	Nine seeds of tap-water group have germinated, average length 12 inches; four seeds of caffeine group, with average length 4 inches.
,,	1% Caffeine	12	,,	30/5/11	
Peas	Tap water	10	,,	6/5/11	Of tap-water group six seeds have germinated, average length 22 inches; of caffeine group five seeds have germinated, average length 18 inches.
,,	1% Caffeine	10	,,	12/5/11	

Name of seed	Previous treatment 24 hours at 25° C. in	Quantity	Date of planting	Sprouts first visible	Condition 4 weeks after planting
Broad beans ...	Tap water	6	1/5/11	12/5/11	Six seeds of tap-water group have germinated, vigorous plants.
,,	1% Caffeine	6	,,	Nil.	
Nasturtium ...	Tap water	14	4/5/11	30/5/11	Six seeds have germinated in the tap-water group, nine in the caffeine. Both are about equally vigorous.
,,	1% Caffeine	14	,,	21/5/11	
Viscaria	Tap water	0·5 g.	,,	16/5/11	Fewer seeds have germinated in the caffeine group. Both groups about equally vigorous.
,,	1% Caffeine	0·5 g.	,,	18/5/11	
Helianthus ...	Tap water	0·5 g.	,,	13/5/11	Fewer seeds have germinated in the caffeine group. Both groups about equally vigorous.
,,	1% Caffeine	0·5 g.	,,	18/5/11	
Nemophila	Tap water	0·5 g.	,,	10/5/11	Many less seeds have germinated in the caffeine group. Both groups equally vigorous.
,, ...	1% Caffeine	0·5 g.	,,	16/5/11	
Wheat	Tap water	11	,,	30/5/11	Ten seeds have germinated in tap-water group. One in the caffeine group.
,,	1% Caffeine	11	,,	4/6/11	
Barley	Tap water	12	,,	30/5/11	Six seeds have germinated in the tap-water group.
,,	1% Caffeine	12	,,	Nil	
Oats	Tap water	13	,,	11/5/11	Eleven seeds have germinated in the tap-water group, two in the caffeine group; the former are the stronger.
,,	1% Caffeine	13	,,	31/5/11	
Canariensis ...	Tap water	10	,,	16/5/11	Six seeds have germinated in the tap-water group.
,,	1% Caffeine	10	,,	Nil	
Eschscholtzia ...	Tap water	0·5 g.	7/5/11	18/5/11	Many more seeds have germinated in the tap-water group, and they are much the stronger.
,,	1% Caffeine	0·5 g.	,,	25/5/11	
Zinnia	Tap water	0·5 g.	,,	15/5/11	In the tap-water group thirty-one seeds have germinated, in the caffeine group nineteen; the latter are the weaker.
,,	1% Caffeine	0·5 g.	,,	17/5/11	

Name of seed	Previous treatment 24 hours at 25° C. in	Quantity	Date of planting	Sprouts first visible	Condition 4 weeks after planting
Marigold	Tap water	0·2 g.	7/5/11	17/5/11	The tap-water group is more numerous and better grown than the caffeine group.
,,	1% Caffeine	0·2 g.	,,	23/5/11	
Gaillardia	Tap water	0·25 g.	,,	21/5/11	The number of seeds which have germinated is about equal. The tap-water group is much more vigorous.
,,	1% Caffeine	0·25 g.	,,	27/5/11	
Chrysanthemum ...	Tap water	0·5 g.	,,	16/5/11	Many more seeds have germinated in the tap-water group, and the seedlings are much stronger than in the caffeine group.
,,	1% Caffeine	0·5 g.	,,	23/5/11	
Linum rubrum ...	Tap water	0·5 g.	,,	16/5/11	Fewer seeds have germinated in the caffeine group, and the seedlings are weaker than in the tap-water group.
,,	1% Caffeine	0·5 g.	,,	21/5/11	
Convolvulus ...	Tap water	0·5 g.	20/6/11	23/6/11	The seedlings in the tap-water group are stronger and more numerous than in the caffeine group.
,,	1% Caffeine	0·5 g.	,,	25/6/11	
Sweet Rocket ...	Tap water	0·5 g.	,,	29/6/11	The seedlings in the tap-water group are stronger and more numerous than in the caffeine group.
,,	1% Caffeine	0·5 g.	,,	10/7/11	
Coreopsis	Tap water	0·3 g.	,,	2/7/11	The seedlings in the tap-water group are stronger and more numerous than in the caffeine group.
,,	1% Caffeine	0·3 g.	,,	5/7/11	
Lavatera	Tap water	0·5 g.	,,	23/6/11	The seedlings in the tap-water group are stronger and more numerous than in the caffeine group.
,,	1% Caffeine	0·5 g.	,,	25/6/11	
Nasturtium ...	Tap water	16	,,	29/6/11	The seedlings in the caffeine group are more numerous, both groups about equally vigorous.
,,	1% Caffeine	16	,,	27/6/11	

REFERENCES

1. Bokorny, *Pflüger's Archiv.*, CXXXVII, p. 470, 1911.
2. Armstrong, *Journal of Physiology*, XL, p. 22, 1910.
3. Waller, *Journal of Physiology*, XL, p. 49, 1910.
4. Bokorny, *Biochem. Zeitschr.*, XXXVI, p. 83, 1911.